LINKING SHORT AND LONG TERM SEDIMENT DELIVERY TO MORPHOLOGY AND ACOUSTIC PROPERTIES OF CONTINENTAL MARGINS

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LONG TERM GOALS

Develop numerical models useful for the simulation of sediment delivery and accumulation on continental margins over time scales of tens to thousands of years. Model predictions will help us understand the evolution of the sediment characterisitcs on continental margins through sea level fluctuations, climate change, and other relevant environmental factors. ONR interests include the development of a numerical predictor of the acoustic signature of remote margins based on a region's geological history.

SCIENTIFIC OBJECTIVES

1) Model sediment delivery and deposit formation on a continental slope. Predict delivery to the shelf-slope break from fluvial point or line sources.
2) Model major influences (climate, sea-level, tectonics) on processes that control slope morphology and stratigraphy. Include the effects of: a) external forcing mechanisms; b) short-term delivery of sediment; c) 2D simulations of individual mass movements (submarine slides, debris flows and turbidity currents); d) acoustic characterization of slope deposits; and e) excess pore pressure on slope failure.

APPROACH

1. The Sediment Delivery Model should include:
A) effects of fluctuating sea levels on sediment input by coupling the rate and direction of sea level change with hinterland climate and landscape, as controls on the dynamics of river plumes, and thus the rate of deposition and physical properties of depositing sedimentary units within slope environments.
B) effects of coastal currents on the behaviour of plume dynamics, i.e. is there a separation of sand deposition on the inner shelf from mud deposition both alongshore and offshore, as influenced by alongshore transport.
C) multiple river sources out from the coastline, both at high stand and low stands of sea level.
D) both hyperpycnal (bottom) and hypopycnal (surface) plumes. Do hyperpycnal events influence margins?
2. The Acoustic Seascape-Stratigraphic Model should see:
A) climate/river models linked to seascape evolution models and geotechnical slope stability models.
B) inclusions of 1D turbidity current and Bingham yield debris flow models.
C) expansion to 2D transport algorithms.
D) attenuation and scattering schemes should be applied to synthetic seismic and predictions made of the Eel River margin.

WORK COMPLETED

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Compiled input data on digital landscape and seascape terrain, sea level and climate for the Eel River margin during the Holocene. Models FACIES and DELTA were combined into one model (SEDFLUX) for increased speed and ease in computation. SEDFLUX was updated with surge and continuous turbity current subroutines (INFLO), debris flow subroutine (BING), compaction subroutine (COMPACT). Sensitivity tests comparing debris flow models SKRED and BING were completed. SYNSEIS was modified to run with SEISUNIX (Colorado School of Mines). HYDROTREND, the climate-discharge simulator, was expanded to include the effects of acquifers, with test runs complete on the Liard River Basin. The 2-D PLUME model now includes the effects of coastal currents on the behaviour of plume dynamics. PLUME model runs were tested against observations of the 1995 Eel River flood deposit and 1997 flood plume concentrations. A simulation of the Eel Margin during the Holocene was completed.

RESULTS

We now have prediction methods for simulating the discharge and the sediment load of ungauged rivers flowing into the ocean. The method compares favorably with USGS observations on the Eel River, including our ability to predict the 400 yr return interval (e.g. 1964) flood of the river. With such a robust model we are able to presently simulate past or future climate effects on the production and delivery of sediment to the ocean. Our plume model can now be coupled with offshore buoy data (wind and currents), to simulate the basic features of coastal plumes under flood conditions. By applying the SEDLUX model to the Eel River margin under present conditions, we have simulated the development of future offshore deposits. We predict that in about 2000 years, a large submarine slide will occur over the present Humboldt slide zone (a site of paleo slides). In 3000 years the coastline will have prograded out to near the modern shelf-slope break. We also predict that hyperpycnal flows will occur every 10 or so years off the Eel River, lasting for a few hours to a day. Longer return interval floods will deliver hyperpycnal flows that could last 2 to 3 days. These events will deliver much sediment directly to the continental slope.

IMPACT/APPLICATIONS

We are on the path to predict acoustic properties of the seafloor of continental margins, based on process based modeling and remote data input (i.e. satellites). Realistic numerical models offer the possibility of making predictions where field data is limited. The impact of floods and or storms on the acoustic character and features of continental margins can then be examined at will.

TRANSITIONS

Results of our modeling efforts have been shared with participants at Old Dominion Observatory (Swift et al.) who have incorporated them into their own modeling efforts. Model runs of the Eel River Margin have been made for USGS participants (Field, Lee). Models have been transferred to MOBIL Technology Center. Our seismic simulator has been used in cooperative work with St. Anthony Falls Hydraulic Lab’s flume efforts. Negotiations with the IGBP-LOICZ (Land-Ocean Interaction Coastal Zone) program that includes participants from 80 countries are underway for the cooperative sharing of each other’s models and data bases.

RELATED PROJECTS

MOBIL Technology Center (Cullick, Sarg, Gouveis, Levin) supported INSTAAR efforts (Bahr, Pratson, Hutton, O’Grady) to develop a data base on continental margin morphology, sedimentology, oceanography and tectonics. Parameters are being linked into super-variables to determine the effective influence of past history, tectonic setting, and sediment delivery and redistribution. The two STRATAFORM margins are included in the data base.

Work with G. Parker, C. Paola (U.Minneapolis), in developing the continental margin flume simulator, has progressed with application of the INSTAAR-SYNSEIS model (Pratson, Syvitski, O’Grady) to their flume results.

COLDSEIS program involving particpant from 12 countries has completed its seismic atlas glaciated margins and special issue of Marine Geology.

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